would be obliged to have a diameter of rather more than four miles, say four miles, and the distances from the source of sound to the hole through which it passes, and from that again to the place where the sound is listened to, would have to be 4000 miles each.

"It is remarkable that the existence of rays, which formed the great stumbling-block in the way of the early reception of the theory of undulations, is now shown to belong to a class of phenomena, those of diffraction, the complete and marvellously simple explanation of which afforded by the theory of undulations now forms one of the great strongholds of that theory."

In connection with the Lecture on the *Senses*, by Sir W. Thomson, which has recently appeared in NATURE (vol. xxix. pp. 438, 462) we may take the following passage. [At the same time it may be well to remark, in passing, that Sir W. Thomson omits altogether the Sense of *Rotation*, which seems to be fully established by the researches of Crum Brown, De Cyon, Flourens, Mach, &c. He also distinguishes between the Senses of Touch and of Heat, making the so-called Muscular Sense a case of the former; while it seems more probable that Touch and Heat are the same sense, and the Muscular sense an independent one.]

"As regards the mode of perception, while there are analogies between sound and light there are at the same time notable differences. In sound, the tympanum of the ear is thrown mechanically into vibration, and the nerves of hearing are mechanically affected, as a mechanical disturbance of a point on the surface of the body is made known by the sense of touch. But in light, just as we have seen reason to believe that it is the disturbance of the ultimate molecules, or of their constituent parts, by which the vibratory motion which constitutes light is in the first instance communicated from ponderable matter to the ether, so we have reason to think that when light is absorbed what takes place is that the disturbance of the ether is communicated, not to portions of matter regarded as forming portions of a continuous elastic body, but to the ultimate molecules of which matter consists, or to their constituent parts. It may be that temporary chemical changes are thereby produced in the ultimate filaments of the nerves of the retina, in which case the sense of sight would be more analogous to the sense of taste than to that of touch."

As a specimen of the firm, yet cautious, way in which the Lecturer meets the grand difficulty of his position, take the following :—

"In studying this subject, one can hardly fail to be struck with the combination of these two things :—the importance of the ends, the simplicity of the means. When I say the importance of the ends, I use a form of expression which is commonly employed as expressing design. And yet on that very account we must be on our guard against too narrow a view. When we consider the subject of vision in its entirety, the construction of the recipient organ as well as the properties of the external agent which affects it, the evidence of design is such, it seems to me, as must to most minds be irresistible. Yet if I may judge of other men's minds by my own, it is rather in the construction of the recipient organ than in the properties of the agent that affects it that the evidence of design is so strongly perceived. And the reason of this may be that we are here dealing with what more nearly resembles design as we know it in ourselves. Man takes the laws of matter as he finds them; the laws of cohesion, of the conversion of liquid into vapour, of the elasticity of gases and vapours, and so forth; and in subserviency to those laws he constructs a machine, a steam-engine for instance, or whatever it may be; but over the laws themselves he has absolutely no control. Now when we contemplate the structure of the eye we think of it as an organ performing its functions in subserviency to laws definitely laid down, relating to the agent that acts upon it, laws which are not to be interfered with. We can, it is true, go but a little way towards explaining how it is that through the intervention of the eye the external agent acts upon the mind. Still, there are *some* steps of the process which we *are* able to follow, and these are sufficient to impress us strongly with the idea of design. The eye is a highly specialised organ, admirably adapted for the important function which it fulfils, but, so far as we can see, of no other use; and this very specialisation tends to make the evidence of design simpler and more apparent. But when we come to the properties of the external agent which affects the eye, we begin to get out of our depth. These more nearly resemble those ultimate laws of matter over which man has no control; and to say that they were designed for certain important objects which we perceive to be accomplished in subserviency to them, seems to savour of presumption. It is but a limited insight that we can get into the system of nature; and to take the very case of the luminiferous ether, while as its name implies it is all-important as regards vision, the present state of science enables us to say that it serves for one object of still more vital importance; we seem to touch upon another; and there may be others again of which we have no idea."

At the end of the work we are told that the two volumes, which are to follow this, are to deal with

II. *Researches in which Light has been used as a means of investigation*, and

III. *Light, considered in relation to its beneficial effects.*

The former of these we may hope to have in a year from the present time; for the final volume we must wait a year longer. But in the meantime let us be thankful for the first instalment, which is a masterpiece of simplicity and strength; and be grateful to the Commission, and the Trustees, to whom we are so very directly indebted for it. And, above all, let us lay to heart the valuable lesson which the Author has drawn from the story of the two rival theories of Light, and of their chief supporters, a lesson good for all time :—

"It may be said, If the former theory is nowadays exploded, why dwell on it at all? Yet surely the subject is of more than purely historical interest. It teaches lessons for our future guidance in the pursuit of truth. It shows that we are not to expect to evolve the system of nature out of the depths of our inner consciousness, but to follow the painstaking inductive method of studying the phenomena presented to us, and be content gradually to learn new laws and properties of natural objects. It shows that we are not to be disheartened by some preliminary difficulties from giving a patient hearing to a hypothesis of fair promise, assuming of course that those difficulties are not of the nature of contradictions between the results of observation or experiment and conclusions certainly deducible from the hypothesis on trial. It shows that we are not to attach undue importance to great names, but to investigate in an unbiased manner the facts which lie open to our examination."

On this it would be impertinent to make any farther comment. P. G. TAIT

OUR BOOK SHELF

Absolute Measurements in Electricity and Magnetism. By Andrew Gray, M.A., F.R.S.E. (London: Macmillan and Co., 1884).

THIS book, which is mainly a reprint of a series of papers on absolute measurement of electric currents and poten-

tials which appeared in these columns a short time ago, but with some additional matter, must, from the clear explanation of the principles involved in the different methods of measurement, take a high position as an educational work, and, from the care with which details of manipulation are in many parts described, form a valuable laboratory guide.

The author begins by explaining Gauss's method of finding the horizontal intensity of the earth's magnetism. Instead of describing an "instrument-maker's" magnetometer, and showing how with this expensive luxury H may be determined, he gives simple, clear, and full directions for constructing, with such common materials as are to be found in any laboratory, all that is necessary for making this determination with great accuracy.

A description of the tangent galvanometer in some of its forms and an explanation of some of the units naturally follow. Here, by treating each unit separately with many illustrations depending on the aspect from which they are viewed, the author has succeeded in giving them a reality which students often find it difficult to believe they possess.

The next two chapters are devoted to a description of the construction and graduation of Sir W. Thomson's "Graded Galvanometers." These instruments possess so great a range, and are, when used carefully in the laboratory, so accurate and convenient, though rather delicate for an engine-room, that an exact description from headquarters of their construction, of the precautions which must be observed in their use, and of the means of graduating them is especially valuable.

The various methods employed in measuring any resistance from that of a thick copper rod to that of a piece of gutta-percha are given, and in many cases explained by numerical examples.

The methods by which the energy due to direct or to alternating currents may be measured is explained—in the latter case on the assumption that the current strength varies harmonically with the time.

The chapter on the measurement of intense magnetic fields is especially interesting, for the methods given, depending on the use of suspended bits of wire attached by threads to pendulum weights, or equally simple and easily contrived devices, show how the experimenter may in many cases be independent of the elaborate work of the instrument-maker. C. V. B.

Field and Garden Crops of the North-Western Provinces and Oudh. By J. F. Duthie, B.A. F.L.S., Superintendent of the Saharanpur Botanical Gardens, and J. B. Fuller, Director of Agriculture, Central Provinces. Part 2. With Illustrations.

AS a work of reference it will be very valuable, for it contains well-arranged details of some of the more important crops under cultivation, and the information is well and systematically arranged. Care has been taken in each case to secure a complete but still a concise statement, which is sufficient to guide the cultivator in all the specialities of management necessary to secure successful results. A good drawing illustrates each crop treated of, and its several cultivated varieties, and with these we have carefully-prepared descriptions of each plant in succession, and its general history. The districts within which the cultivation can be successfully extended are also set forth with great clearness and precision. For accuracy of details, in a very accessible form, this work leaves little to be desired.

A Treatise on Higher Trigonometry. By the Rev. J. B. Lock. (Macmillan, 1884.)

THIS is the promised complement to the same writer's "Treatise on Elementary Trigonometry," which we noticed very favourably in these pages at the time of its appearance (vol. xxvi. p. 124). It is concerned principally with series, the errors which arise in practical work, and the use of subsidiary angles in numerical calculations.

A short chapter on the use of imaginaries is justified by the position this subject holds in the London University Examinations, and no apology is needed for the space assigned to an account of, and a collection of exercises upon, the hyperbolic sine and cosine. We have read the text carefully, and though almost of necessity there are numerous typographical mistakes, only one or two (for $2a\cos 2\theta$, p. 127, line 3, read $a\cos 2\theta$) will inconvenience a student. In addition to the numerous examples in the text, there are fourteen specimen papers from Cambridge and other examinations.

The only article to which we take exception is § 9, the proof of which may be, if we mistake not, considerably simplified. The book can be confidently recommended to the use of advanced pupils in our schools, and will meet the wants of most students in our Universities.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Teaching Animals to Converse

YOU did me the honour some weeks ago (January 3, p. 216) to insert a letter of mine, containing suggestions as to a method of studying the psychology of animals, and a short account of a beginning I had myself made in that direction.

This letter has elicited various replies and suggestions which you will perhaps allow me to answer, and I may also take the opportunity of stating the progress which my dog "Van" has made, although, owing greatly no doubt to my frequent absences from home, and the little time I can devote to him, this has not been so rapid as I doubt not would otherwise have been the case. Perhaps I may just repeat that the essence of my idea was to have various words, such as "food," "bone," "water," "out," &c., printed on pieces of cardboard, and after some preliminary training, to give the dog anything for which he asked by bringing a card.

I use pieces of cardboard about 10 inches long and 3 inches high, placing a number of them on the floor side by side, so that the dog has several cards to select from, each bearing a different word.

One correspondent has suggested that it would be better to use variously coloured cards. This might no doubt render the first steps rather more easy, but, on the other hand, any temporary advantage gained would be at the expense of subsequent difficulty, since the pupil would very likely begin by associating the object with the colour rather than with the letters; he would, therefore, as is too often the case with our own children, have the unnecessary labour of unlearning some of his first lessons. At the same time the experiment would have an interest as a test of the condition of the colour-sense in dogs. Another suggestion has been that, instead of words, pictorial representations should be placed on the cards. This, however, could only be done with material objects, such as "food," "bone," "water," &c., and would not be applicable to such words as "out," "pet me," &c.; nor even as regards the former class do I see that it would present any substantial advantage.

Again, it has been suggested that "Van" is led by scent rather than by sight. He has no doubt an excellent nose, but in this case he is certainly guided by the eye. The cards are all handled by us, and must emit very nearly the same odour. I do not, however, rely on this, but have in use a number of cards bearing the same word. When, for instance, he has brought a card with "food" on it, we do not put down the same identical card, but another with the same word; when he has brought that, a third is put down, and so on. For a single meal, therefore, eight or ten cards will have been used, and it seems clear, therefore, that in selecting them "Van" must be guided by the letters.